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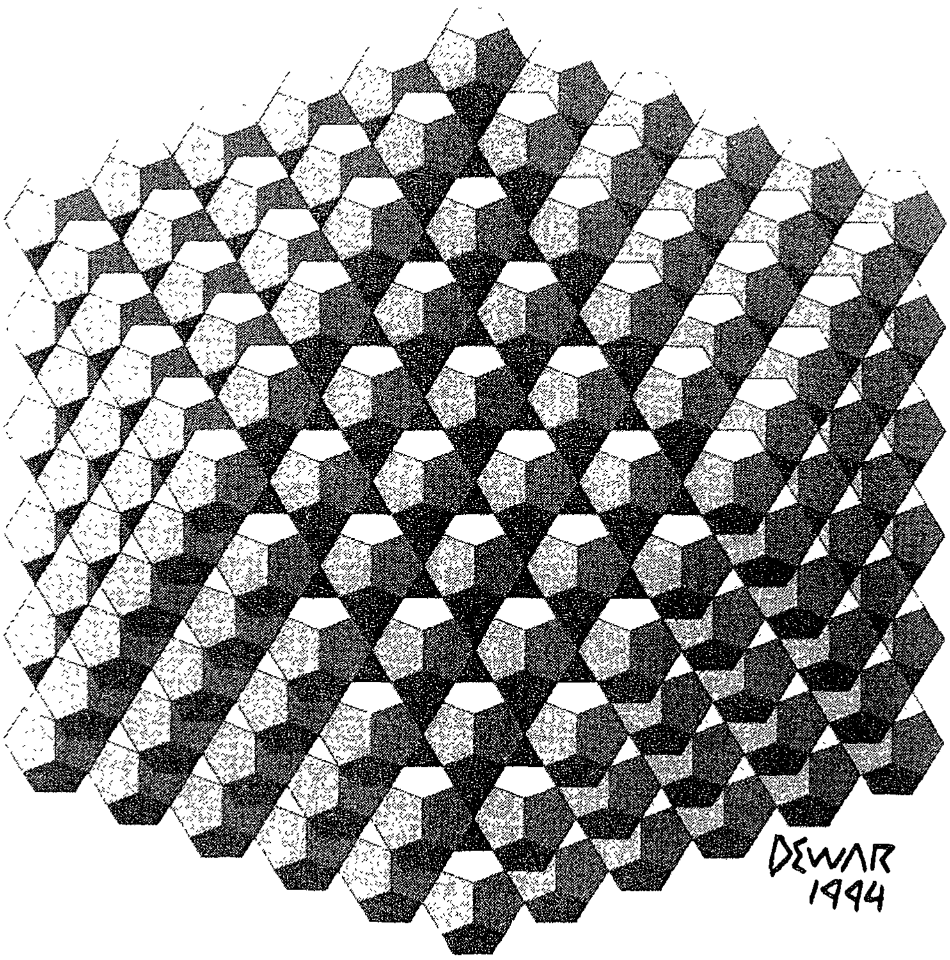

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ON THE BIOLOGICAL ADVANTAGE OF CHIRALITY

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It is well known that the main molecules of life, such as proteins, RNA, DNA, etc. are chiral. The purpose of this presentation is to show that this is not just an artifact, but that chirality may present a significant biological advantage for intra-molecular organization and function.[1-4] For this purpose it is necessary to distinguish between physical and geometric chiralities,[5-6] where physical chiralities may enable the generation of modes of motion of organized nature. Such an effect can be produced by a chiral device that interacts with a given medium. Two macroscopic examples for these are the windmill and the electric cell, where the relevant media are the air flow (wind) and the electrolite, respectively. In the case of the windmill, if the shape of the vanes contained reflection symmetry, the windmill "wouldn't know in which direction to rotate". The chiral nature of the structure of the vanes interacting with the wind enables it to choose one preferred direction, clock or anti-clockwise, out of two possible ones. In the case of the electric cell the chemical asymmetry between the electrodes enables the current in a wire to choose one direction of two possible ones. Such a mode of interaction is to be referred to as "Chiral Interaction" (C.I.). For macroscopic devices there are two modes of motions generated by C.I., namely a massive rotation and an electric current. A third example that is meant

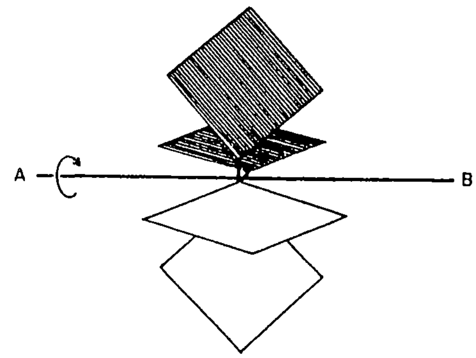

Figure 1: A scheme of the Crookes' radiometer. The physical chirality in this device is in the colors of the wings, i.e. black and silver, and not in the shape of the wings being perfectly symmetric.

to emphasize the physical vs. geometric nature of chirality is the Crookes' radiometer (see Figure 1). When light is shone at the wings of this device, it is reflected by the silver and absorbed by the black ones. This generates an air expansion near the black surfaces which pushes the wings in the direction of the black color, so that a selective rotational motion is generated. From geometric view-point, the silver and black wings are perfectly symmetric, but they differ in color, i.e., in optical absorption coefficient, which is of physical nature. This is a fine example of physical chirality.

For microscopic, or molecular systems, such as proteins the relevant medium for C.I. is the ionic motion in a polar solvent. Since the mass ratio between ions and the protein molecule is quite small, the resulting C.I. can only be in the form of an intrinsic perturbation, or current, flowing in one preferable direction out of two possible ones. No massive rotation of the protein is permitted.[7] A physical model for such a C.I. is presented.[3]

An important feature of all C.I. is the existence of an interface[7] that separates the chiral device from the interacting medium. Such an interface is obvious for macro-devices. In the electric cell, C.I. takes place at the interface separating between the electrodes and the electrolite. In the case of molecular systems, such as proteins, it is well known that all soluble proteins become globular before they can function as enzymes. Globular structure enables the formation of an interface separating between the solvent and the interior of the molecule.

Few interesting results of C.I. in molecular systems can be drawn.[3] The persistent motion of perturbation, in one preferred direction out of two possible ones prevents the molecule (protein) from reaching thermal equilibrium, which makes the interacting system nonergodic. It is thereby assumed the nonergodicity[3,4] is a necessary condition for molecular evolution in nature. Micro systems that reach readily thermal equilibrium are not likely to evolve. Another interesting result is that C.I. is a mode of intrinsic organization created out of chaotic ionic motion in a solvent by the presence of chirality and certain structural details, including the motion of a medium. It can also be shown that C.I. in molecular systems may enable to select one chirality out of two possible ones with the aid of a magnetic field.[1–4,8] A few structural details in proteins obtain physical significance due to the possible viability of C.I. An example for this is the presence of nitrogen in amino-acids, the building blocks of protein, that becomes necessary in order to generate an electric dipole moment being a chiral element in the system.

In conclusion, this domain of research is still in its infancy and it requires certain experimental supports which have been proposed.[2,3,8] In addition a better physical and chemical insights into the nature of function of biomolecules is required in order to tie them up with C.I.

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